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MECHANICAL PROPERTIES OF Ti-8Al-1Mo-1V ALLOY AT ROOM AND CRYOGENIC TEMPERATURES.

MRG 246

August 2, 1961

PREPARED BY: J.L. CHRISTIAN

GENERAL DYNAMICS/CONVAIR

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SUBJECT: Mechanical Properties of Ti-8Al-1Mo-1V Alloy at Room and Cryogenic Temperatures.

ABSTRACT: The tensile (F_{ty}, F_{tu} and elongation), weld tensile (F_{tu}, elongation and joint efficiency) and notched tensile strengths and notched/unnotched tensile ratios were determined at 78°, -100°, -320° and -423°F on titanium 8Al-1Mo-1V sheet material. The alloy was tested in the mill-annealed condition. The data obtained show a continuous increase in the yield strength, tensile strength and weld tensile strength with reduction in testing temperature. Weld joint efficiencies were 100% at all testing temperatures. Elongations of base metal and weld joints were nearly the same at 78°, -100° and -320°F but decreased sharply at -423°F. Notched tensile strengths and notched/unnotched tensile ratios indicate adequate toughness for structural applications at 78°, -100°, and -320°F. However, the decrease in notched tensile strength at -423°F and the resulting low notched/unnotched tensile ratio indicate poor toughness at -423°F. This alloy is not recommended for structural applications at liquid hydrogen temperatures (-423°F).

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SUBJECT: Mechanical Properties of Ti-8Al-1Mo-1V Alloy at Room and Cryogenic Temperatures.

INTRODUCTION

The mechanical properties of a large number of titanium alloys have been determined at cryogenic temperatures. Report MRG-189, dated 14 October 1960, gives the mechanical properties of nine titanium alloys at cryogenic temperatures. Of these alloys, only one, the Ti-5Al-2.5Sn material, retains sufficient toughness for structural applications at -423°F (boiling point of liquid hydrogen). The titanium-8Al-1Mo-1V alloy has higher tensile and yield strengths at 78°F and is more easily rolled into thin gauge sheet material than the Ti-5Al-2.5Sn material. It was therefore the purpose of this investigation to determine if the Ti-8Al-1Mo-1V alloy would be suitable for use at cryogenic temperatures.

MATERIALS

The Ti-8Al-1Mo-1V alloy used in this investigation was supplied by Titanium Metals Corporation of America, in 0.096 inch sheet, heat number M-9519. Table 1 presents the chemical analysis and properties as supplied by certificate of test from the supplier. The material was tested in the as received condition.

PROCEDURE

Blanks for tensile specimens, 9" x 1½", were identified and sheared in directions both longitudinal and transverse to the direction of rolling. Panels of the alloy were inert-arc fusion welded on production equipment and sheared into tensile blanks. Smooth and welded (EMG-D-1) and notched (MRG-D-10, Notch "A") tensile specimens were machined. A minimum of three tensile tests in the longitudinal and two tests in the transverse directions were performed on both smooth and notched specimens at room temperature (78°F), -100°F (alcohol and dry ice), -320°F (liquid nitrogen), and -423°F (liquid hydrogen). Strain measurements were made by use of extensometers (cryo-extensometer at low temperatures) and a continuous stress strain recorder. Total elongations on both base metal and welds were determined over a 2" gauge length made by scribe marks with a precision block and read under 10X magnification. Strain rates were maintained at 0.002"/"/min. until 0.2% offset yield and then 0.15"/min. until fracture. The 50,000# Baldwin testing machine, strain recorder, strain pacer, and extensometers are periodically checked and approved by standards laboratory.

RESULTS AND DISCUSSION

The mechanical properties of Ti-8Al-1Mo-1V at ambient and cryogenic temperatures are given in Table 2. The room temperature properties agree quite well with those obtained by the supplier (see Table 1). Yield and tensile strengths of base metal and tensile strengths of butt welded joints increased with decrease in testing temperature (about 75% from 78°F to -423°F). Elongations of base metal and welded specimens were nearly the same at 78°, -100°, and -320°F but decreased significantly at -423°F. Weld joint efficiencies were 100% at all testing temperatures. Notched tensile strengths increased from 78°F to -320°F but decreased at -423°F. Notched/unnotched tensile ratios decreased with reduction in testing temperatures.

Based on the data obtained in this investigation it is believed that the Ti-8Al-1Mo-1V alloy retains adequate toughness for structural use at -320°F, but should not be used for structural applications at liquid hydrogen temperatures (-423°F).

SUMMARY

1. Yield and tensile strengths of base metal and tensile strengths of fusion welds increase about 75% from 78°F to -423°F.

2. Elongations of base metal and welds are nearly the same at 78°, -100° and -320°F but decrease at -423°F.

3. Weld joint efficiencies are 100% at all testing temperatures.

4. Notched tensile strengths and notched/unnotched tensile ratios indicate sufficient toughness for structural applications at 78°, -100° and -320°F but not at -423°F.

TABLE 1

Chemical Composition and Properties of Ti-8Al-1Mo-1V *
0.096" Sheet; Mill Annealed 1350°F, 8 Hours; Heat M-9519

Chemistry

Alloying Element	Percent
Aluminum	7.8
Molybdenum	1.1
Vanadium	1.0
Iron	0.09
Carbon	0.02
Nitrogen	0.012
Oxygen	0.08
Hydrogen	0.013

Properties

Direction	Yield Strength	Tensile Strength	Elong.	Bend Test (105° Press Brake)
Long.	137,400 psi	145,400 psi	17%	2.9
Trans.	135,000 psi	145,100 psi	15.5%	2.9

* Certificate of Test from Titanium Metals Corporation of America, Test A-4816, dated August 10, 1960.

TABLE 2

Mechanical Properties of Ti-8Al-1Mo-1V Alloy
0.096" Sheet, Annealed, TMCA, Heat # M-9519

Test Temp °F	Direction	F_{ty} ksi	F_{tu} ksi	Elong. %	Notched (K_t=6.3) Tensile Strength (ksi)	Notched/Unnotched Tensile Ratio	Heliarc Butt Weld T.S. (ksi)	Weld Elong. (%)	Joint Eff. (%)
78	Long.	136	142	15.5	156		151	13.0	
"	"	135	142	15.5	155		145	13.5	
"	"	135	142	16.0	155				
	Avg.	135	142	15.7	155	1.09	148	13.3	100
"	Trans.	133	141	15.0	152				
	"	133	141	15.0	154				
	Avg.	133	141	15.0	153	1.09			
-100	Long.	150	160	16.0	156				
"	"	156	165	16.0	154				
"	"				170				
	Avg.	153	163	16.0	160	0.98			
"	Trans.	153	164	15.0	164				
	"	153	165	16.5	168				
	Avg.	153	165	15.8	166	1.01			
-320	Long.	196	216	15.0	198		213	4.0	
"	"	195	214	16.0	185		219	14.5	
"	"	196	215	15.0	194				
	Avg.	196	215	15.3	192	0.89	216	9.3	1.00
"	Trans.	192	209	14.5	176				
"	"	189	210	13.5	199				
	Avg.	191	210	14.0	188	0.90			
-423	Long.	234	245	3.0	177		251	2.5	
"	"	233	240	3.0	196		250	2.5	
"	"	222	240	3.0	189				
	Avg.	230	242	3.0	187	0.77	251	2.5	1.00
"	Trans.	214	245	8.0	176				
"	"	211	236	3.0	166				
	Avg.	213	241	5.5	171	0.71			

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